where the Tuolumne River crosses the west boundary of the quadrangle to 12,590

feet at Mount Conness, a peak along the Sierra Divide. Much of the quadrangle lies

between 8,000 and 10,000 feet and is snowbound during the winter months. Granite domes and glacial features that were formed by processes that either operated in the recent past or are still operating are principal attractions of the area and are all well known. However, other geologic features that were produced in the distant past—hundreds of millions of years ago—are less well known but no less interesting. The most abundant rocks in the quadrangle are granitic, and the oldest rocks are remnants of metamorphosed sedimentary and volcanic rocks that were intruded by molten magmas that solidified to the granitic rocks. Much younger glacial deposits, talus, and alluvium locally mantle the older rocks. METAMORPHOSED SEDIMENTARY AND VOLCANIC ROCKS AND

HYPABYSSAL INTRUSIVE ROCKS Only scattered remnants of the old metamorphosed sedimentary and volcanic rocks now remain, but before the granitic magmas intruded and disrupted them, they covered the entire area. Metamorphic rocks occur in three parts of the quadrangle: the Saddlebag Lake area north of Tioga Pass in the northeast corner, south and west of Ireland Lake in the northwest-trending ridge that includes Parsons

Peak, and small scattered masses in the west and north. The only mass of metamorphic rocks large enough and coherent enough to allow reasonable interpretations of its structure and history is northeast of Tioga Pass. The oldest rocks, designated metasedimentary strata, undifferentiated, lie east of Saddlebag Lake along Tioga Crest. They include quartzofeldspathic hornfels, calcsilicate hornfels, pelitic hornfels, and conglomerate derived from sandstone; limestone, marl, sandy limestone, and calcareous quartzite; mudstone; and conglomerate. Most of these rocks were deposited in the margins of an ancient ocean, but the lenses of conglomerate may have been deposited in stream channels. The conglomerates are predominantly in the west part of the unit, which is probably the upper part, and they appear to reflect uplift, deformation, and erosion of the underlying strata as the period of marine deposition came to an end. The strata are folded into complex patterns that are the result of more than one episode of deformation; they show cleavage and dip steeply in most places. Because outcrops are poor and discontinuous, structures within this unit are not designated on the map. The age of these strata is not known exactly; poorly preserved molds of crinoid stems and distorted horn corals on the west side of Saddlebag Lake near its north end indicate a late Paleozoic age (360-240 m.y.).

Unconformably overlying these strata is a succession of nonmarine volcanic and associated sedimentary strata. These strata dip steeply to the west or are vertical in most places and are progressively younger to the west. Although the strata were tilted steeply to the west after they were deposited and before they were intruded by granitic rocks of the Cretaceous Tuolumne Intrusive Suite, presumably during the widespread Late Jurassic Nevadan orogeny, they are neither so strongly nor so complexly deformed as the underlying marine sedimentary strata. Folds were recognized only near the south end of the succession, north of Gaylor Lakes. Most of the units in the succession were deposited on land as pyroclastic and lava flows perhaps within or adjacent to a caldera, but the youngest and most westerly unit was deposited in a lake. Isotopic dating of whole rocks by the Rb-Sr method indicates that the lower part of the succession is Triassic (about 225 m.y.) and that the upper part is Jurassic (about 185 m.y.).

A still younger group of volcanic and associated sedimentary strata are present in and around Gaylor Peak. These strata were downdropped against the adjacent strata along a curved bounding fault. The downdropped block continues to the southeast into the Mono Craters quadrangle where a wedge of similar strata is in fault contact on both sides with late Paleozoic marine strata. Rb-Sr data indicate that the strata in the Mono Craters quadrangle are Early Cretaceous (140-100 m.y.), and presumably the strata in the Tuolumne Meadows quadangle are of the same

The strata in the ridge south and west of Ireland Lake, which includes Parsons Peak, in the southeast corner of that quadrangle, and north of Hooper Peak and at Rodgers Lake, in the northwest corner of the quadrangle, are also chiefly volcanic rocks and probably were deposited within the same general time span as the succession of metavolcanic rocks east of Saddlebag Lake in the northeast corner of the quadrangle. Quite different metamorphic rocks are present in small discontinuous remnants between May Lake and Glen Aulin. These rocks are composed of quartzite, calc-silicate hornfels, schist, and marble and, before metamorphism, were sand, marl, clay-shale, and limestone that were deposited in a marine environment. No fossils have been found in these strata, and their age is unknown. Similar appearing strata elsewhere in the Sierra Nevada are of early Paleozoic (500-400 m.y.) age and of Late Triassic and Early Jurassic age (225-175 m.y.).

PLUTONIC ROCKS—TUOLUMNE INTRUSIVE SUITE Granitic rocks underlie more than 90 percent of the quadrangle, but large areas are covered by glacial deposits. The granitic rocks vary markedly in appearance: some are fine grained and some coarse grained, some are dark and some light colored, some are equigranular and some have large blocky megacrysts of feldspar that glisten in the sun, and some have black euhedral prisms of homblende and books of biotite. The different granitic rocks are in different bodies (plutons) that were emplaced at different times and that meet along sharp contacts or are separated by thin septa (or screens) of metamorphic rock. The different bodies solidified from masses of molten magma, which were generated deep in the Earth's crust or upper mantle and rose into the upper crust, displacing the metamorphic and older granitic rocks with which they came in contact along the way. When the granitic rocks were emplaced, the present ground surface was deep in the Earth, buried under perhaps as much as 10 km of rock. Uplift and consequent removal of these overlying rocks by erosion created the surface we see today.

Although many different bodies of granitic rock are exposed within the quadrangle, the largest, youngest, and most interesting ones belong to the Tuolumne Intrusive Suite. Somewhat older granitic rocks are present in the northwest and southeast parts of the quadrangle, but the Tuolumne Intrusive Suite occupies most of the quadrangle. The formations that make up the Tuolumne Intrusive Suite are nested one within the other, the oldest at the margins and the youngest in the core of the suite. The tonalite of Glen Aulin and the granodiorite of Kuna Crest are the marginal formations on the west and east sides, respectively. Successively inward from them are the equigranular facies of the Half Dome Granodiorite, the porphyritic facies of the Half Dome Granodiorite, the Cathedral Peak Granodiorite, and the Johnson Granite Porphyry in the core of the suite. All of these rocks were emplaced about 87 m.y. ago, according to isotopic age determinations and were derived from a common parent source at depth. Nevertheless, they change progressively inward, becoming lighter colored and coarser gained except for the Johnson Granite Porphyry, which is fine grained.

The textural and compositional changes in the Tuolumne Intrusive Suite can be seen quite clearly by examining the rocks for about 3 km along the trail that runs north from May Lake, then stopping at roadcuts along the Tioga Road between Olmstead Point, 21/2 km southwest of Tenaya Lake, and the Visitor Center at Tuolumne Meadows. The rock along the trail between the parking area at the foot of the trail and May Lake is in the equigranular facies of the Half Dome Granodiorite, but at May Lake the trail enters a thin septum of quartzite and calc-silicate hornfels, which separates the Tuolumne Intrusive Suite from the granodiorite of Mount Hoffman to the west. North of May Lake, the trail passes across light-colored quartzite, but about a kilometer to the north, where it turns northeast to descend a steep slope, the quartzite is in sharp contact with the dark-gray, fine-grained tonalite of Glen Aulin. Farther down the trail, the rock becomes progressively lighter colored and coarser grained, and within a few hundred meters at the bottom of the steep slope, the rock is much like the rock exposed at Olmstead Point. It is the equigranular facies of the Half Dome Granodiorite, and the rocks at the three places look alike because they are all about equidistant from the west contact of the Tuolumne Intrusive Suite. The rock is characterized by black prisms of hornblende as much as 2 cm long, shiny flaky hexagonal books of biotite a centimeter across, and tiny

Along the highway between Olmstead Point and Tenaya Lake, the appearance of the rocks changes very little, but east of the picnic ground at Murphy Creek, large rectangular feldspar crystals (called megacrysts) appear and increase in abundance toward the east end of the lake. This rock is the porphyritic facies of the Half Dome Granodiorite. In this span, many outcrops appear striped. The stripes are actually layers within the rock, which grade from fine grained and dark on one side to medium or coarse grained and light colored on the other. These layers were caused by different flow rates in the magma, which sorted the crystals according to size. The rate of flow was slower in the fine-grained, dark side of the layer and progressively faster toward the coarse-grained, light-colored side. The sorting was caused by differences in velocity across the layers. In the fine-grained dark side the difference in velocity was much greater across a width of a few millimeters than across the same width in the coarse-grained light-colored side. Velocity differences cause crystals to be dispersed to parts of the layer where the velocity differences are less, and large

crustals are dispersed more effectively than small ones. The dark crystals are in the fine-grained part of the layer because they are small, and not because they are heavier. The boundary surfaces between layers mark sharp discontinuities in the

In most places, the contact between the porphyritic facies of the Half Dome Granodiorite and the Cathedral Park Granodiorite is sharp, but along Tioga Road it is gradational. East of Tenaya Lake, opposite the steep west face of Pywiack Dome, the tabular feldspar megacrysts of the Half Dome Granodiorite give way eastward through a mixed zone about 50 m wide to larger blocky megacrysts that characterize the Cathedral Peak Granodiorite. Eastward from Puwiack Dome along Tioga Road, the Cathedral Peak Granodiorite becomes progressively lighter colored because of decreasing amounts of dark-colored minerals, and the feldspar megacrysts become smaller and less abundant. The rock near Fairview Dome at the west edge of Tuolumne Meadows contains only small, sporadically distributed feldspar mega-

At Tuolumne Meadows, the Cathedral Peak Granodiorite gives way abruptly to the fine-grained Johnson Granite Porphyry. This formation underlies a relatively small area about 2 km across from east to west and about 8 km long. A coherent central mass, but with very irregular boundaries, is bordered by dikes of similar rock that ramify adjacent parts of the Cathedral Peak Granodiorite. The Johnson Granite Porphyry is well exposed in outcrops north and across the road from the Visitor Center, and a sharp contact with the Cathedral Peak Granodiorite is exposed in a flat-lying outcrop a few tens of meters south of the Tuolumne River. Eastward to Tioga Pass, changes in the texture and composition of the rocks of the Tuolumne Intrusive Suite duplicate, in reverse order, the changes between May Lake and Tuolumne Meadows, but much of the area along the Tioga Road east of Tuolumne Meadows is covered with glacial moraine, and the granitic rocks are poorly and discontinuously exposed.

The changes from the margins inward in grain size, texture, and composition have attracted the attention of geologists, because an explanation would bear on the problem of the origin of the diversity of compositions and textures common to genetically related suites of granitoids the world over. The dark-colored marginal rocks are composed of assemblages of minerals that crystallized at high temperatures, and inward the rocks are composed of mineral assemblages that crystallized at progressively lower temperatures. The obvious inference is that the suite solidified from the margins inward with falling temperature. The sharp contacts between the different formations undoubtedly represent surges of magma from below which eroded the inward solidifying carapace and produced discontinuities. No evidence has been found to indicate that magma reached the surface in volcanic eruptions until the Johnson Granite Porphyry was emplaced, but the abrupt decrease in grain size in the Johnson and the presence of small vugs that reflect bubbles in the magma are best explained by loss of volatiles from the magma. Loss of volatiles causes a magma to crystallize at a higher temperature than it would if it had retained the volatiles. Undoubtedly the volatiles were lost upward to the surface, and there is a good possibility that they were lost in an eruption.

The underlying cause of the progressive inward compositional and textural changes is still uncertain. The more traditional view is that crystals separated from the melt as it cooled and either stuck to the walls or settled downward, thus progressively impoverishing the core magma of minerals that crystallize at high temperatures. Another possibility that is suggested by studies of isotopes of rubidium and strontium is that the composition of the parent magma at depth, rather than remaining constant, changed progressively as the result of incorporating parts of the lower crust that would melt at low temperatures, thus enriching the parent magma in low-temperature constituents. The relative importance of these two processes is yet to be determined.

LITTLE DEVILS POSTPILE Along the south side of the Tuolumne River, about 11/2 km southeast of Glen Aulin, is an irregularly shaped plug (or neck) of dark trachybasalt averaging about 100 m across, which intrudes the Cathedral Peak Granodiorite. This plug is locally called "Little Devils Postpile," but it resembles the well-known Devils Postpile, farther south in the Sierra Nevada along the upper San Joaquin River, only in that both are composed of dark volcanic rock. The Devils Postpile is a lava flow in which spectacular hexagonal columns developed during cooling, whereas Little Devils Postnile is an intrusive plug lacking conspicuous columns, which undoubtedly was the feeder for flows that have been entirely eroded away by ice and water. The plug has attracted the attention of geologists, because it has melted adjacent parts of the Cathedral Peak Granodiorite. The age of the plug has been inferred to be about 9.4±2 m.y. from counts of fission tracks in the minerals apatite and sphene which were extracted from the partly melted granodiorite. If this age is correct, the plug was intruded well before the beginning of the great ice age of the Pleistocene Epoch, which began about 2 m.y. ago.

GLACIAL FEATURES At the height of the last stage of the ice age of the Pleistocene, which peaked about 18,000 years ago and ended about 10,000 years ago, almost the entire area of the Tuolumne Meadows quadrangle was buried under the immense Tuolumne Ice Field, which was more than 300 m thick in places. Only the highest peaks such as Vogelsang, and Parsons Peak in the south, Cathedral and Unicorn Peaks near the center, and Mount Conness and North Peak in the northeast projected above the almost continuous ice field. Ice from this field flowed generally westward along the tributaries to the Merced and Tuolumne Rivers, but east of the Sierra Divide it flowed southeastward along Lee Vining Creek. As the great ice field dwindled because of warming summers and decreasing winter precipitation, small glaciers persisted in high cirque basins. However, the existing small glacier on the northeast side of Mount Conness is not a relict of the Tuolumne glacier—it dates from a shorter lived and less severe period called the Little Ice Age, which peaked 3,000 to

4,000 years ago. This great ice field has left its mark indelibly on the landscape, shaping bedrock and leaving behind vast deposits of morainal till. Small tell-tale features are everywhere. Rock surfaces have been highly polished and grooved with fine striae by rocks that were dragged over bedrock surfaces by the moving ice. Accompanying the striated surfaces are chatter marks-curved fractures, shaped like the crescent moon, whose horns point in the direction the glacier was moving. They were caused by the moving rocks in the ice pressing against and fracturing the underlying bedrock. Glacial erratics are everywhere. These are boulders, some of enormous size, that were carried by the glacier from distant places, then dropped as the ice melted away.

But the largest glacial features are the glacial valleys and cirques cut by the plucking action of ice and moraines. Stream-cut valleys are V-shaped in cross section, with narrow bottoms and convex sides that flatten upward. As glaciers flowed along these stream-cut valleys, they widened the bottoms and steepened the walls of the valleys to form U-shaped canyons like those of Lyell Canyon and along Tenava Creek. Smaller glaciers in upland regions widened and deepened the basins in which they formed to produce cirque basins that filled with lakes after the glaciers disappeared. Ireland Lake is a fine example of a lake-filled cirque, or tarn. Where one cirque is enlarged and encroaches on another, a knife-edge ridge, called an arête, is formed such as the one that lies between Vogelsang and Hanging Basket

Moraines are collections of rocky material carried in and deposited by glaciers. Most of the morainal material within the Tuolumne Meadows quadrangle was deposited at the bottoms of glaciers as ground moraine, along their sides as lateral moraines, and within glaciers as medial moraines. Medial moraines lie within glaciers and extend downstream from the juncture of coalescing glaciers or from a rocky protuberance that supplies rock debris. Lateral and medial moraines are ridge-like, whereas bottom moraine is hummocky and marked by pits that formed where chunks of ice were left behind as the glacier wasted away. A fine display of lateral moraines can be seen on Moraine Flat northeast of Tuolumne Meadows; their crests are indicated on the map. Ground moraine is well displayed at Dana Meadows, near the east edge of the quadrangle southeast of Tioga Road.

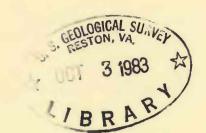
GRANITE DOMES A magnificent display of granite domes is present between Tenaya Lake and Tuolumne Meadows-Pywiack Dome, Polly Dome, Medlicott Dome, Fairview Dome, and many others. Domes are formed by exfoliation—the splitting off of rock slabs along curved surfaces that dip in the direction of the surface in which they occur, but a little less steeply. Thus sharp edges are gradually rounded off. If carried on long enough, exfoliation leads to rounded moundlike forms that are covered with rock slabs. Exfoliation is caused by the release of pressure on the rocks because of erosion and is aided by the freezing and thawing of water that has seeped into

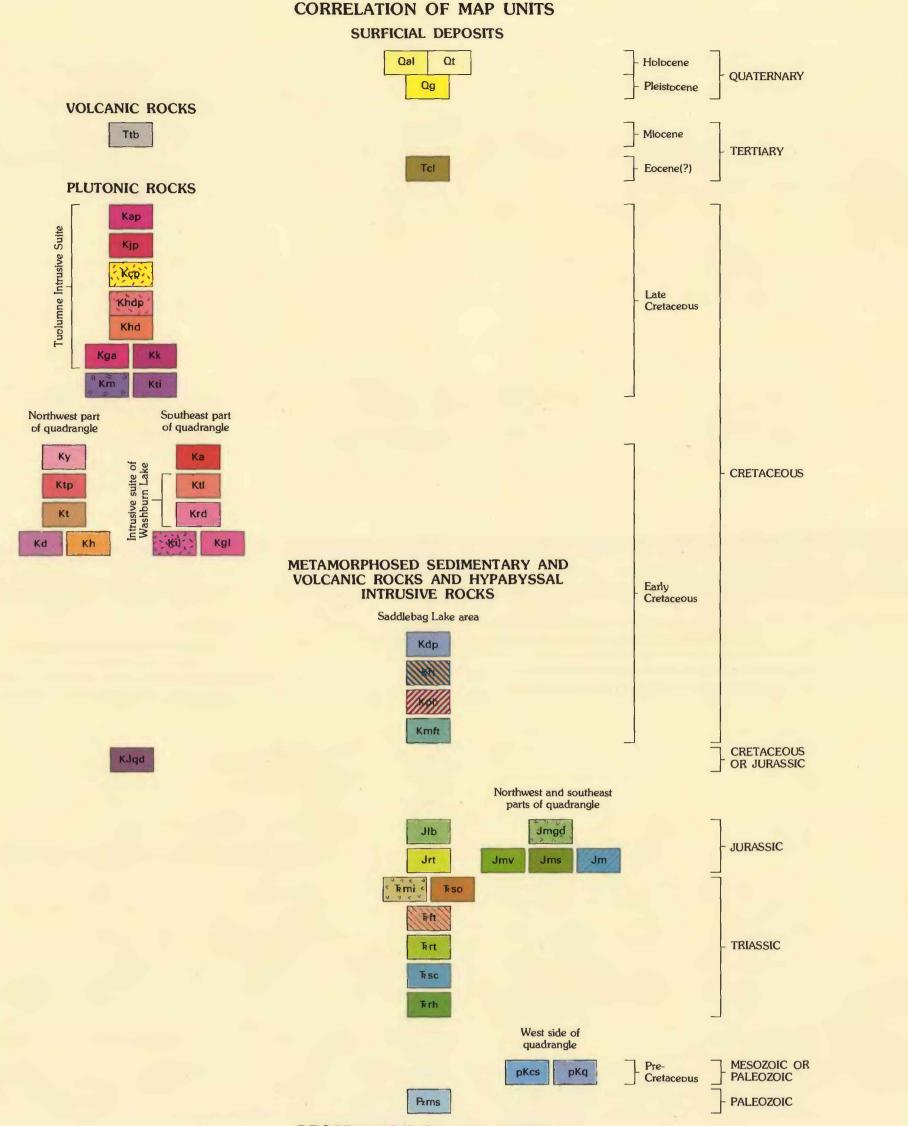
Although the domes of Yosemite are the best known in the Sierra Nevada because of their sparsely vegetated stark beauty, domes are also present in lower parts of the range, where they generally draw little attention because they are covered by forest or are in lowland areas. The formation of domes occurs only in massive rock and requires that steeply dipping joints are not open. Domes are absent along Tioga Road east of Tioga Pass where closely spaced, steeply dipping or vertical joints are present. The opening of the steeply dipping joints in this area probably results from the proximity to the eastern escarpment of the Sierra Nevada, which allows lateral movement toward the east and opening of the steep joints.

Geology mapped by P. C. Bateman, R. W. Base from U.S. Geological Survey, 1956 Kistler, D. L. Peck and A. J. Busacca Polyconic projection. 1927 North American datum 10,000-foot grid based on California coordinate system, zone 3 1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue CONTOUR INTERVAL 80 FEET NATIONAL GEODETIC VERTICAL DATUM OF 1929 QUADRANGLE LOCATION

GEOLOGIC MAP OF THE TUOLUMNE MEADOWS QUADRANGLE, YOSEMITE NATIONAL PARK, CALIFORNIA

Paul C. Bateman, Ronald W. Kistler, Dallas L. Peck, and Alan Busacca 1983





DESCRIPTION OF MAP UNIT

SURFICIAL DEPOSITS Qal ALLUVIUM—Chiefly sand and gravel underlying meadows

Ot a TALUS—Rock glaciers shown diagrammatically by curved lines Og GLACIAL DEPOSITS—Crests of morainal ridges shown by dot pattern INDURATED CONGLOMERATE

VOLCANIC ROCKS TRACHYBASALT PLUG—Fission-track age of sphene and apatite: 9.4 m.y.

PLUTONIC ROCKS **TUOLUMNE INTRUSIVE SUITE** APLITE AND PEGMATITE DIKES AND SMALL MASSES—Mostly late differentiates of the Tuolumne Intrusive Suite JOHNSON GRANITE PORPHYRY—Fine-grained equigranular granite that locally contains K-feldspar phenocrysts and miarolitic cavities. Consists of a large mass that forms the core of the Tuolumne Intrusive Suite and thin dikes

marginal to the central mass CATHEDRAL PEAK GRANODIORITE—Medium-grained hornblende-biotite granodiorite that contains conspicuous blocky megacrysts of K-feldspar 2 to 5 cm across. Megacrysts are largest and most abundant in the margins of the body and are progressively less abundant and smaller inward. Foliation is generally weak. U-Pb zircon age: 88±2 m.y.

HALF DOME GRANDODIORITE—Two facies recognized Porphyritic facies—Medium-grained porphyritic hornblende-biotite granodiorite with a seriate texture. Biotite and hornblende commonly in euhedra. Abundance of K-feldspar megacrysts increases inward toward contact with Cathedral Peak Granodiorite. Megacrysts are generally smaller than those in the Cathedral Peak Granodiorite, are tabular rather than equant, and commonly are a little more than 1 cm across and 2 to 3 cm long

Equigranular facies—Medium-grained equigranular granodiorite. Characterized by euhedral homblende prisms 1 to 3 cm long, biotite books as much as 1 cm across, and conspicuous sphene ONALITE OF GLEN AULIN—Dark-colored rock of variable composition ranging from fine-grained quartz diorite in the west to medium-grained granodiorite

at the east contact with Half Dome Granodiorite and Cathedral Peak Granodiorite. U-Pb zircon age: 86±2 m.y. GRANODIORITE OF KUNA CREST—Dark-colored medium-grained hornblende-biotite granodiorite. Generally coarser grained than the tonalite of Glen Aulin on the opposite side of the Tuolumne Intrusive Suite, but, nevertheless, considered to be its approximate equivalent GRANODIORITE OF MONO DOME—Medium-grained equigranular granodiorite

and quartz diorite. Contains pyroxene as discrete crystals and as cores in hornblende. Rb-Sr whole-rock age: 93±6 m.y. (Late Cretaceous). Previously considered Jurassic by Kistler (1966) RANODIORITE OF TIOGA LAKE—Medium-grained dark-gray rock. Angular olagioclase and ragged, partly chloritized amphibole crystals are set in a matrix of fine-grained K-feldspar, quartz, plagioclase, and biotite

Northwest part of quadrangle

Ky YOSEMITE CREEK GRANODIORITE OF ROSE (1957)—Predominantly coarsegrained, dark-gray biotite-hornblende tonalite; grades to granodiorite. Locally is porphyritic and contains plagioclase phenocrysts GRANODIORITE NORTH OF TUOLUMNE PEAK—Small masses and dikes of hornblende-biotite granodiorite

LEUCOGRANITE OF TEN LAKES—Coarse-grained white mottled to gray anhedral quartz crystals. Rb-Sr whole-rock age: 98±4 m.y. Previously called alaskite of Ten Lakes and considered Jurassic by Kistler (1973). GRANODIORITE OF DOUBLE ROCK—Coarse-grained porphyritic granodiorite. Locally abundant lensoid mafic inclusions accompanied by alined tabular K-feldspar phenocrysts give the rock a streaked appearance. Previously con-

sidered Jurassic by Kistler (1973) GRANODIORITE OF MOUNT HOFFMAN—Coarse-grained locally porphyritic biotite granodiorite and granite. Southeast margin of pluton in west side of quadrangle (Mount Hoffman pluton) is locally sheared. Rb-Sr whole-rock age: 98±4 m.y. Previously considered Jurassic by Kistler (1973)

Southeast part of quadrangle APLITE MASS NORTH OF BERNICE LAKE INTRUSIVE SUITE OF WASHBURN LAKE

GRANITE OF TURNER LAKE-Porphyritic biotite granite and felsic granodiorite. Contains abundant phenocrysts of potassium feldspar in a medium-

GRANODIORITE OF RED DEVIL LAKE—Equigranular granodiorite and granite forming the outer unit of the intrusive suite of Washburn Lake. Zoned from inclusion-rich mafic biotite-hornblende granodiorite at the outer margin to biotite granite at the inner contact with the granite of Turner Lake. South of Gallison Lake, the granodiorite is strongly sheared. U-Pb zircon age: 98±2 m.y.

GRANITE OF IRELAND LAKE—Medium- to coarse-grained porphyritic granite, much of it strongly sheared LEUCOGRANITE OF GALLISON LAKE—Fine-grained felsic granite

QUARTZ DIORITE, DIORITE, AND GABBRO—Mafic plutonic rocks ranging greatly in composition, grain size, and texture. Probably includes rocks of dif-METAMORPHOSED SEDIMENTARY AND VOLCANIC

ROCKS AND HYPABYSSAL INTRUSIVE ROCKS Saddlebag lake area DACITE PORPHYRY—Fine-grained gray rock composed of plagioclase phenocrysts in a matrix of plagioclase, quartz, and opaque minerals FELSIC TUFF—Quartz and feldspar crystals abundant, and collapsed pumice fragments present locally. Includes thinly laminated calc-silicate rock composed

of quartz, feldspar, epidote, and opaque minerals PELITIC HORNFELS—Thin-bedded fine-grained metasiltstone composed of tiny grains of plagioclase, muscovite, quartz, and opaque minerals. Larger plagioclase

grains are present locally. Crossbeds occur in some places NTERSTRATIFIED MAFIC AND FELSIC TUFFS—Includes a lens of pebble conglomerate. Tuffs are composed chiefly of quartz, biotite, plagioclase, and opaque TUFFACEOUS LAKE BEDS—Thinly bedded and fine grained; composed chiefly of volcanogenic sediment. Common minerals include plagioclase, quartz, biotite,

hornblende, and opaque minerals. Calcareous layers contain calcite, diopside, hornblende, epidote, and trace amounts of scheelite RHYOLITE ASH-FLOW TUFF-Light-gray tuff with a few flattened pumice fragments. Phenocrysts of quartz and plagioclase are in a fine-grained matrix. Rb-Sr whole-rock age about 185 m.y. MAFIC HYPABYSSAL INTRUSIVE ROCK—Probably of andesitic composition.

Mass northeast of Dore Cliff is porphyritic MONZONITE OF SADDLEBAG AND ODELL LAKES—Altered biotitehornblende monzonite. Probably hypabyssal and cogenetic with Triassic volcanic rocks. Rb-Sr whole-rock age: about 220 m.v. MAFIC FLOWS AND TUFF—Pebble conglomerate at base of unit is overlain by tuffaceous beds of intermediate composition. Mafic flows at top of unit. Rb-Sr

whole-rock age: 224±14 m.y. RHYOLITE ASH-FLOW TUFF-Light-gray tuff with many flattened pumice fragments generally 1 to 5 cm long. Phenocrysts of quartz and plagioclase are embedded in a fine-grained matrix TUFFACEOUS SANDSTONE, SILTSTONE, AND CONGLOMERATE—Lenses of rhyolite tuff are present in a few places. Conglomerate lenses apparently were

deposited in stream channels. Flattened pebbles are identical with rock in Paleozoic strata down section to the east RHYOLITE TUFF—Mostly bedded METASEDIMENTARY STRATA, UNDIFFERENTIATED—Quartzofeldspathic hornfels, calc-silicate hornfels, and carbonaceous marble in the northeast corner

of the quadrangle Northwest and southeast parts of quadrangle MICROGRANODIORITE—Hypabyssal intrusive rock east of Vogelsang Lake.

Ranges in composition and texture from microgranodiorite to granite porphyry and intrusive rhvolite METAVOL CANIC ROCKS SOUTH OF IRELAND LAKE—Also includes septum 2. km northwest of Hooper Peak in the northwest corner of the quadrangle and a small mass 2½ km west of Babcock Lake in the south-central part. Predominantly tuff-breccia of intermediate composition containing angular to rounded fragments that average 2 to 10 cm across but are as large as 75 cm METASEDIMENTARY ROCKS WEST OF IRELAND LAKE—Thinly laminated

calc-silicate hornfels and quartz-biotite schist with epidote layers and "eyes." Locally interbedded with volcanic conglomerate UNDIFFERENTIATED METASEDIMENTARY AND METAVOLCANIC ROCKS NORTH OF HOOPER PEAK—Pattern indicates abundant dikes of the adjacent plutonic rocks

West side of quadrangle CALC-SILICATE HORNFELS, QUARTZITE, AND SCHIST-In pendants and septa between Glen Aulin and May Lake MASSIVE QUARTZITE—Associated with other metasedimentary rocks in metamorphic remnants between Glen Aulin and May Lake

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Contact—Showing dip. Dotted where concealed; Y, younger rock; O, Fault—Dashed where inferred; dotted where concealed

Anticline—Showing trace of axial surface Syncline—Showing trace of axial surface

Zones of pervasive shearing Strike and dip of beds Vertical—Arrow shows top direction

Inclined—Right side up Vertical—Top direction not determined Inclined—Top direction not determined

with symbols for bedding Inclined Bearing and plunge of lineation. Combined with symbols for bedding

Strike and dip of cleavage in metamorphic rocks. May be combined

Strike and dip of primary foliation in plutonic rocks. Defined by preferred orientation of mineral grains and lensoid mafic inclusions

Foliation not apparent Vertical—Strike variable Vertical—Dip variable

Vertical—Strike and dip variable Inclined—Strike variable Inclined—Dip variable Inclined—Strike and dip variable

Strike of vertical secondary foliation in plutonic rocks—Shown by the preferred orientation of quartz blebs. Combined with symbols for Strike of cataclastic foliation

Strike and dip of flow layering in plutonic rocks. Arrow points in direction

of increasing grain size

Strike and dip of dikes Vertical felsic dike

Inclined felsic dike Inclined mafic dike

